This submittal presents modifications to the Revisions to the Phase II Pawtuxet River Proposal (October 1993) for the RCRA Facility Investigation of the CIBA-GEIGY facility at Cranston, RI. These modifications address comments received from the USEPA in the Conditional Approval letter dated April 15, 1994.

The text for Chapter 6 has been revised (including a new Table 6-2). This revised section replaces Chapter 6 text in the Revisions to the Phase II Pawtuxet River Proposal. Two pages in Appendix E have been revised. Revised pages E-23 and E-24 replace the existing pages in this appenxix. The text for Appendix F also has been revised; it replaces the original version of Appendix F.

The "Responses to Comments" following this Preface indicates where each of the USEPA comments is addressed.

**Responses to Comments**
**USEPA's April 15, 1994 Conditional Approval Letter**
**Phase II Pawtuxet River Proposal**

CHAPTER 6 - PHASE II ENVIRONMENTAL ASSESSMENT PROPOSAL

1. Page 6-11 proposes an acute toxicity test to identify the most sensitive species-media pair but there is no discussion on how this will be followed up. Since we are primarily interested in chronic effects, the absence of an observed acute toxic effect does not rule out sublethal effects observed using chronic toxicity tests. Sublethal effects add to a weight-of-evidence regarding community or population assessment endpoints, such as changes in community structure or reduction of effective populations. **This issue must be addressed in the final report.**

   *This issue will be addressed in the RFI Report.*

2. Page 6-14 proposes to identify "Endangered" species as part of the literature review (Task 2) but should identify "Threatened" species and sensitive habitats as well. Also, the literature review should identify potentially affected species by trophic levels. This comment also applies to the field surveys being conducted in Task 3 and Task 4 and is necessary for developing a food chain or food web. **These issues must be addressed in the final report and in the proposal as amended pages.**

   *These issues have been addressed on page 6-12, Section 6.5.2; on page 6-14, "Characterization of Aquatic Populations"; and on page 6-21, "Riparian Surveys". These issues also will be addressed in the RFI Report.*

3. Page 6-25 must be revised to define "no significant increase" in the paragraph immediately preceding Riparian Surveys and "significant concern" needs to be defined in the next paragraph. **This must be addressed in the proposal as amended page(s).**

   *This comment has been addressed on page 6-20, "Screening-Level Risk Assessment"; and "Riparian* Surveys".

4. Page 6-8 lists the standards for comparing community indices (EPA comment #17 from 9-10-93) by inserting examples in parentheses (richness, evenness, and diversity). These

examples are assessment endpoints, but there is no explanation as to how they will be measured (measurement endpoints). Also, the original comment refers to how these indices will be attributed to site-related contaminants when physical conditions may be confounders. This part of the comment has not been addressed. **These issues must be addressed in the final report.**

*These issues will be addressed in the RFI Report.*

5. Page 6-8 does not fully address EPA comment #18 from 9-10-93. Specific indices have been included but the remaining request for elaboration on the specific indices has not been addressed, and is important to focusing the assessment. **This must be addressed in the final report.**

   *This comment will be addressed in the RFI Report.*

6. Page 6-25 does not address EPA comment #34 from 9-10-93 on animal analysis for site related chemicals. If analysis is not going to be conducted, then the river proposal must explain how the study will address the resulting uncertainty. **This must be addressed in the proposal as amended page(s).**

   *This comment has been addressed on page 6-15, "Fish Population Survey".*

7. Page 6-28 appears to have addressed EPA comment #35 from 9-10-93 but there is no discussion of migratory birds in the assessment and there are plans to conduct just winter and summer observations. There needs to be a determination of the migratory value of the site and identification of known seasonal transients. Site breeders, or only those endemic to the site, should not be the only concern. Species may inhabit adjacent areas and use the site for foraging only. If this is to be eliminated then a rationale should be provided that addresses reproduction and the viability of the population not the length of exposure. **This must be addressed in the final report.**

   *This comment will be addressed in the RFI Report.*

8. Pages 6-31 & 32 do not fully address EPA comment #39 from 9-10-93. Assessment endpoints should be differentiated from measurement endpoints. Assessment endpoints have been identified, but the proposed measurement endpoints remain unstated. This assessment will have little value without specifically connecting a measurement to the endpoint. **This must be addressed in the proposal as amended page(s).**

*This comment has been addressed on pages 6-25 and 6-26, "Determination of Ecological Endpoints", and in Table 6-2.*

9. Page 6-32 should clarify what "this" refers to in the sentence "Very few data exist for evaluations such as this, especially ... specific basis". Also, what "data" will be used to "evaluate certain community and population endpoints"? **This must be addressed in the proposal as amended page(s).**

   *This comment has been addressed on pages 6-25 and 6-26, "Determination of Ecological Endpoints", and in Table 6-2.*

10. Page 6-33 does not adequately address EPA comment #40 from 9-10-93. "Upstream" has not been adequately defined and remains unspecific. A rationale for why a "reference" area is appropriate should be provided. Once data is in hand, an evaluation should be conducted since the data may not support the chosen area. More thought needs to be given to how reference stations will be located or determined to be appropriate. Also, any uncertainty should be identified and the "etc" in the parentheses needs explanation. **The first part of this comment must be addressed in the final report. The last sentence of this comment must be addressed in the proposal as amended page(s).**

    *The first part of this comment will be addressed in the RFI Report. The last sentence of this comment has been addressed on pages 6-26 and 6-27, "Risk Analysis".*

11. Page 6-33 does not adequately address EPA comment #44 from 9-10-93. The section titled Uncertainty Analysis is still incomplete. There are uncertainties inherent in sampling, analysis (especially detection limits), and field surveys, just to name a few. As stated in the original comment, each task of the assessment will have uncertainties. The final report should include a balanced presentation of uncertainties, those that potentially result in underestimates as well as overestimates of ecological effects or risk. **This must be addressed in the proposal as amended page(s) and included in the final report.**

    *These issues have been addressed on page 6-27 and 6-28, "Uncertainty Analysis", and also will be included in the RFI Report.*

APPENDIX E - PHASE II MODELING OF THE PAWTUXET RIVER

12. Page E-23 does not state which model input parameters will be varied for the sensitivity analysis. Will assumptions and simplifications also be varied? Once the model

sensitivity has been evaluated, how will this be used to "identify the level of precision required in the assignment of model parameter values? **These questions must be addressed in the proposal as amended page(s).**

*These issues have been addressed on revised pages E-23 and E-24, "Sensitivity Analyses".*

APPENDIX F - BASIS FOR PHASE II RELEASE CHARACTERIZATION... REACH

13. Page F-1 states in the section titled Biological Considerations that "The Pawtuxet River does not provide such a substrate and benthic biota below the surficial sediments are not expected to be common near the site". This argument should be expanded and there should be a discussion on what will be done if benthic biota are found below the surficial sediments near the site. **This must be addressed in the proposal as amended page(s) and explained in the final report.**

    *This comment has been addressed on revised page F-1 and also will be addressed in the RFI Report.*

# 6

# PHASE II ENVIRONMENTAL ASSESSMENT PROPOSAL

## 6.1 OVERVIEW

This chapter proposes a work plan for the Phase II environmental assessment of the Pawtuxet River as part of the Public Health and Environmental Risk Evaluation (PHERE) in the RCRA Facility Investigation of the CIBA-GEIGY facility at Cranston, Rhode Island. The environmental assessment work plan has been prepared in accordance with current USEPA guidance. However, the procedures for environmental risk assessments are not as well defined as are those for human health risk assessment. The current scientific literature is not adequate to address most individual endpoints. The database is inadequately defined as compared to that for human health risk assessments. The following documents, specifically applicable to ecological assessments, guided the development of this work plan:

- *Supplemental Risk Assessment Guidance for the Superfund Program* (USEPA Region I, 1989);
- *Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual* (USEPA, 1989);
- *Ecological Assessments of Hazardous Waste Sites: A field and laboratory reference document* (USEPA, 1989b);
- *Sediment Toxicity Evaluation: Phase I, Phase II, and Phase III Modification of Effluent Procedures* (USEPA, 1991);
- *Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents* (USEPA, 1973); and
- *1991 Annual Book of ASTM Standards* (ASTM, 1991).

The Phase II ecological assessment is structured according to the general overview of ecological assessments provided by USEPA Region I (1989) and presented in Figure 6-1. The structure of the site-specific ecological assessment is presented in Figure 6-2 and has six tasks:

- *Task 1* — Toxicity Identification Evaluations;
- *Task 2* — Literature Review;
- *Task 3* — Aquatic Environment Investigations;
- *Task 4* — Terrestrial Environment Investigations;
- *Task 5* — Ecological Assessment of the Pawtuxet River; and
- *Task 6* — Ecological Assessment of the facility.

Non-riparian (i.e., non-riverbank-dwelling) terrestrial investigations (part of Task 4) and the ecological assessment of the CIBA-GEIGY facility (Task 6) are not discussed in this document.

In the Phase II environmental assessment, interrelated investigations will be performed to:

- characterize the biota of the area;
- identify potential sources of impact to the biota attributable to the facility;
- identify receptor populations;
- assess exposure; and
- characterize risk to the environmental receptors.

At the conclusion of the Phase II biological investigations (Tasks 3 and 4), the results from the Phase II hydrological investigation (discussed in Chapter 4) and the Phase II Pawtuxet River release characterization (discussed in Chapter 5) will be incorporated into Tasks 5 and 6 of the Phase II environmental assessment to assess the risk to the environment from site-related contaminants in the Pawtuxet River.

Table 6-1 outlines the work proposed for the Phase II environmental assessment of the Pawtuxet River, including:

- the *data gaps* identified in Phase I (or other *data needs* for Phase II);
- the *strategies* proposed to fill those data gaps or needs;
- the *activities* proposed to implement those strategies; and
- any *contingencies* that could impact the activities proposed.

This chapter is organized around Table 6-1. Section 6.2 of this chapter briefly reviews the results from the Phase I investigations. Section 6.3 presents the data gaps/needs identified from Phase I. Section 6.4 outlines the strategies proposed for the Phase II environmental assessment of the Pawtuxet River and Section 6.5 presents the methods and analyses proposed for implementing those strategies. Finally, Section 6.6 discusses other considerations for the Phase II environmental assessment, including integrating the data with other Phase II studies and contingencies for the activities proposed. The chapter concludes with an overall summary in Section 6.7.

## 6.2 PHASE I RESULTS FOR THE PAWTUXET RIVER

This section summarizes the Phase I investigations involving the Pawtuxet River — the hydrological investigation (part of the physical characterization of the site) and the Pawtuxet River release characterization. Detailed discussions of these results were presented in Chapters 2 and 3 of this document.

### 6.2.1 Phase I Hydrological Investigation

The Phase I hydrological investigation was undertaken along the facility reach and included a literature review, a bathymetry survey, a water discharge survey, suspended sediment discharge monitoring, and a riverbed sediment characterization. The overall goal of the hydrological investigation was to evaluate the physicochemical characteristics of the river with respect to the storage and/or transport of constituents of concern.

The Pawtuxet River has received discharges (in both the past and present) from many industries as well as from several sewage treatment plants. Dating back to the 1700s, forges and textile mills discharged to the Pawtuxet River; privies serving up to 3000 employees were positioned directly over the river. Currently, the waste water treatment plants of the Warwick, West Warwick, and Cranston municipalities, as well as industrial metal platers and jewelry manufacturers, are upstream of the facility.

Water depth ranged from 2 to 9 feet along the facility reach during the bathymetric investigation on 23 July 1990. Pools may have been caused by previous dredging activities or by erosional processes in the river. In general, shallow areas are colonized by aquatic macrophytes. These weed beds may simultaneously cause sediment deposition by creating a baffling effect and prevent erosion by stabilizing the sediment-water interface.

### 6.2.2 Phase I Pawtuxet River Release Characterization

The Phase I release characterization investigated the upstream reach of the Pawtuxet River as a background location, and investigated both the facility and downstream reaches to evaluate the potential impact (if any) of past discharges. Two media of concern, surface water and riverbed sediment, were investigated in each reach; two sampling rounds were conducted on each medium in each reach. In general, the objectives of the Phase I Pawtuxet River release characterization included determining the nature of contamination in Pawtuxet River surface water and sediments, as well as determining if releases from the facility are impacting surface water quality and/or sediments in the river. Chemical analyses of samples, and bioassay tests of organisms exposed to samples, were conducted.

The surface water analytical results were comparable across all three reaches. In general, the same organic analytes tended to be detected in all three reaches, and no PCBs, dioxins, or furans were detected in any samples. A limited number of analytes, and small ranges of concentrations, were detected across all three reaches. This comparability across reaches is to be expected since the river is a very dynamic system and river flow typically is well-mixed from turbulent flow.

The sediment analytical results indicated that the nature of contamination in the facility reach sediments are more extensive than anticipated and are not fully understood. Release characterization sampling and contaminant transport and fate modeling proposed for Phase II will provide information on the temporal and spatial distribution of contaminants.

The Phase I bioassay results indicated no toxicity in the surface waters of the Pawtuxet River in the region of the facility, but indicated toxicity in the river sediments. Sediments sampled from 18 locations (3 upstream, 10 in the facility reach, and 5 downstream) were tested for toxicity. Toxicity was detected in sediments and interstitial waters throughout the facility reach and, to varying degrees, downstream of the site. The most sensitive organism for detecting this toxicity was the larvae of the midge, *Chironomus tentans*. Sediments with the highest toxicity were encountered adjacent to the Production Area; toxicity generally decreased downstream, except that toxicity increased in sediments sampled about 1.5 miles downstream from the site. Currently, there is no explanation for the increased toxicity downstream.

### 6.2.3 Ecological Habitat Description

The site is located in the Pawtuxet River Basin, encompassing an area of about 230 square miles (Metcalf and Eddy, 1983). The Pawtuxet River, which separates the Production and Waste Water Treatment areas from the Warwick Area, is the only surface water body topographically downgradient of the site. Flow in the Pawtuxet River is regulated by two reservoir dams (Scituate Reservoir and Flat Rock Reservoir), the Pawtuxet Cove Dam, and multiple small mill dams throughout the length of the river. The watershed includes rural, urban, and industrial land uses. Woodlands, wetlands, and grasslands exist in the reach of the river investigated. The state of Rhode Island has described the present water quality conditions in the Pawtuxet River as Class D downstream of the Cranston Sewage Treatment Plant; the facility reach is located within this area. Class D waters are suitable for migration of fish and have good aesthetic value, but are not suitable for public water supply, agriculture, swimming, boating, or fish and wildlife habitat.

## 6.3 PHASE I DATA GAPS / PHASE II DATA NEEDS

The Phase I data gaps/Phase II data needs for the Phase II hydrological investigation and Pawtuxet River release characterization were presented in Chapters 4 and 5. Seven data gaps/data needs were identified for the Phase II environmental assessment:

- An ecological characterization of the upstream reach, including basic water quality data and an inventory of biota, is needed to establish baseline conditions.
- Characterization of the biota is needed to determine whether the ecotoxicological effects identified in Phase I have had an impact on the community.
- The vicinity of the site contains a variety of suitable habitats (e.g., woodlands, wetlands, and the river) for resident and migratory mammals, birds, and waterfowl; the identity of possible receptors of site-related constituents needs to be determined.
- The presence or absence of State- or Federally-designated threatened or endangered species or other sensitive natural resources needs to be ascertained.
- The exposure scenarios of the potential receptors to the constituents need to be identified.

- The risk of effects due to exposure needs to be characterized.
- The contribution of constituents to observed toxicity needs to be identified in order to discriminate site-related effects.

## 6.4 STRATEGY FOR THE PHASE II ENVIRONMENTAL ASSESSMENT

The strategy to fill these data gaps/data needs in the Phase II environmental assessment of the Pawtuxet River is based on the first five tasks shown in Figure 6-2:

- Conducting Toxicity Identification Evaluations (Task 1);
- Conducting a Literature Review (Task 2);
- Conducting Aquatic Environment Investigations (Task 3);
- Conducting Terrestrial Environment Investigations (Task 4); and
- Performing an Ecological Assessment of the Pawtuxet River (Task 5).

**Conducting Toxicity Identification Evaluations (Task 1)**

Toxicity Identification Evaluations (TIEs) will be conducted on sediments collected from a total of eight downstream and facility reach locations using procedures based on available USEPA guidelines. The TIEs will assist in describing sources of toxicity and delineating potential site-related impacts on the Pawtuxet River. TIEs are structured into four steps. All steps may not be performed based on necessity and practicality. These steps are:

1. Determining the most appropriate species-media pair.
2. Characterizing the chemical class(es) to which the toxicant(s) belong.
3. Characterizing some specific constituents within these classes.
4. Confirming the cause of toxicity (i.e., the toxicants identified), if necessary.

**Conducting a Literature Review (Task 2)**

A literature review will be conducted to evaluate existing data about the vicinity of the site and the river. Previous environmental studies provide general information on the ecology of the site, but site-specific data on biota will be collected during the Phase II environmental assessment. Several sources will be consulted as part of the literature review to identify endangered species in the project area. The result of this effort will be a species list that will be used in screening-level risk assessments.

**Conducting Aquatic Environment Investigations (Task 3)**
Aquatic environment investigations will involve:

- Conducting a habitat characterization of the Pawtuxet River.
- Conducting a survey of the benthic communities in the Pawtuxet River and in the Waste Water Treatment Area pond.
- Conducting a survey of the fish populations in the Pawtuxet River and in the Waste Water Treatment Area pond.
- Based on the results of the aquatic surveys, assessing the impact of site-related constituents on the aquatic biota by comparing community indices (such as richness, evenness, and diversity as well as the presence/absence of tolerant/sensitive species).

**Conducting Terrestrial Environment Investigations (Task 4)**
Terrestrial environment investigations will involve:

- Site visit
- Conducting a screening-level risk assessment to evaluate potential effects on riparian (riverbank-associated) fauna as identified in the literature.
- Conducting surveys, if necessary, of riparian mammal, herptiles and bird populations.

The results from Task 4 will be integrated with the results from Task 3 and used to support Task 5. (Non-riparian terrestrial environment investigations are not discussed in this chapter.)

**Performing an Ecological Assessment of the Pawtuxet River (Task 5)**
The ecological assessment of the Pawtuxet River will involve:

- Identifying receptor populations based on the results from the biota surveys (in Tasks 3 and 4).
- Assessing the exposure of the ecosystem or biological populations at risk to the site-related constituents based on the results from the hydrological investigation, the Pawtuxet River release characterization, and the biological investigations.
- Evaluating the potential for particular constituents to cause increases in the incidence of particular effects.

- Characterizing potential biological effects based on the results from the field investigations, the exposure assessment, and the toxicity assessment.

## 6.5 METHODS AND ANALYSES FOR THE PHASE II ENVIRONMENTAL ASSESSMENT

This section provides details about the sampling methodology, analyses, and data evaluation to be used in the Phase II environmental assessment of the Pawtuxet River. The methods will describe and analyze the biotic and abiotic components of the existing ecosystem to determine the impacts associated with the potential release of contaminants. The analyses include characterizing the principal ecosystems in the area, determining which biological populations are at risk, characterizing contaminant profiles possibly associated with previously documented effects, and identifying exposure pathways to biological receptors. This section is organized around the five tasks in the Phase II environmental assessment of the Pawtuxet River.

### 6.5.1 Conducting Toxicity Identification Evaluations (Task 1)

In Phase I, bioassay tests conducted on sediments from the Pawtuxet River (discussed in Chapter 3) indicated toxicity to *Chironomus tentans* (midge) larvae in the facility reach and the "far downstream" reach. The extent of the area of impact related to the facility was not defined adequately by these bioassay tests. To determine if the toxicity observed in downstream samples is site-related, identification of the toxicant(s) responsible (or, at least, the general class of the toxicant — e.g., metals, volatile organics, non-polar organics) is highly desirable.

To reach this goal, toxicity identification evaluations (TIEs) will be performed on sediments collected from downstream locations as well as from selected facility reach locations sampled for toxicological and chemical analyses in the Phase I Pawtuxet River release characterization. (The locations that demonstrated high toxicity in Phase I testing will be selected for Phase II sampling.) A total of 8 locations will be sampled for the TIEs; the procedures will be based on USEPA guidelines available for sediment TIEs.

The TIEs will be performed in four steps (shown in Figure 6-3):

1. Determining the most appropriate species-media pair.
2. Characterizing the chemical class(es) to which the toxicant(s) belong.
3. Characterizing some specific constituents within these classes.
4. Confirming the cause of toxicity (i.e., the toxicants identified), if necessary.

Sufficient sediment samples will be collected from each location using a Ponar grab sampler (following the same procedures used in Phase I, described in Appendix B). These samples will be stored on ice in the dark, transported to the aquatic toxicology laboratory, and stored in the dark at about 4°C.

Step 1: Determining the Appropriate Media-Species Pair

The first step of the TIEs is to determine the most appropriate medium and species to use. TIEs originally were designed for the investigation of municipal and industrial waste waters. These procedures cannot be adopted for bulk sediments, so either pore waters or elutriates must be used. Pore waters have been shown to have some applicability in predicting bulk sediment toxicity. Elutriates often have been used for determining toxicity due to resuspension of contaminants in the water column. Since toxicity of bulk sediments has been demonstrated already, these considerations are irrelevant. The aqueous medium that concentrates the toxicants most effectively will be identified and used for further chemical/physical manipulations and determinations in this study.

Species differ in sensitivity to different toxicants or classes of toxicants. Therefore, three different species will be tested in both pore water and elutriate for each sample and the species which is most sensitive to the toxicants present (as measured by an acute LC50) and the media in which it is most sensitive will be identified for each sample tested. Differing species sensitivities indicates different toxicants in samples. Juvenile fathead minnows (*Pimephales promelas*), neonate water fleas (*Ceriodaphnia dubia*), and midge larvae (*Chironomus tentans*) will be tested in both pore water and elutriates. *C. dubia* was tested in pore water bioassays during Phase I; however, a limited number of sediment samples was tested and effects were noted in only two of the six facility reach samples. *C. tentans* was the most sensitive species tested in Phase I sediments; however, bulk sediment (not pore water) was used in the bioassay; bulk sediment is not appropriate for TIE testing.

Furthermore, exposure of *C. tentans* to toxic constituents often is not related to pore water concentrations, so species-media sensitivity tests are essential for determining the most sensitive species-media pair to be used for further testing. Differences in species-media pairs between sampling locations can help delineate the area of impact related to the facility. If patterns of toxicity differ between locations so that a site-related zone of contamination can be defined, then further testing may not be necessary. A sensitive practical species (instead of the most sensitive species) may be used for further testing if the patterns of toxicity between the two species are the same.

<u>Step 2: Characterizing the Toxicant Chemical Classes</u>

The class characterization step relies on the principles of chemistry to simplify and separate the toxicants and uses living organisms to track the toxicity. Each procedure used is designed to render a specific class of compounds unavailable to the organisms tested in the ensuing fraction of the sample. The reduction, enhancement, or lack of change in the toxicity of the fraction as compared to the original sample indicates the potential for a toxicant to be present from that class of constituents. The procedures and toxicity tests used during the characterization include:

- oxidant reduction tests using sodium thiosulfate (for oxidizers or reducers);
- EDTA chelation tests (for metals);
- aeration tests using pH adjustments (for volatile organics);
- C18 solid-phase (or other suitable) column extraction tests (for non-polar organics);
- filtration tests (for filterables); and
- graduated pH tests (for ammonia).

The results from the downstream reach will be compared with those from the facility reach. It is possible that this comparison will indicate the presence of different classes of toxicants in different samples, which may help define a site-related zone of contamination. These results will be used to determine which (if any) additional tests are needed to meet the delineation objective. Additional tests on complex samples intended to identify specific toxicants may not be possible.
If this is the case, the evaluation may stop here.

<u>Step 3: Characterizing Specific Constituents in Classes</u>

The objective of Step 3 is to identify the suspected toxicant(s). Some general guidance may be furnished by the outcome of Step 2, but usually both separation and concentration procedures will be needed to meet the objective. Often, C18 solid phase extraction, followed by methanol fractionation or high pressure liquid chromatography fractionation, followed by GC/MS analyses, is used. Identified constituent concentrations will be compared to concentrations in the scientific literature (if available) which have been shown to cause toxicity. The results from the downstream reach will be compared with those from the facility reach. If needed, testing will proceed to Step 4.

<u>Step 4: Confirming the Cause of Toxicity</u>

The confirmation step uses a group of procedures to confirm the suspected cause of toxicity. Rarely does one procedure or test conclusively prove the cause of toxicity; typically, all practical approaches are used to provide a "weight of evidence" that the cause of toxicity has been identified. The approaches that are often useful in providing such a "weight of evidence" are:

- correlation;
- observation of symptoms;
- relative sensitivity;
- spiking;
- mass balance estimates; and
- adjustments of water quality characteristics (such as pH and hardness) and measuring the resulting changes in toxicity.

The toxicants identified for each downstream site will be compared to each other and to the site-related contaminants in the facility reach to help identify the zone of site-related impacts, if needed.

### 6.5.2 Conducting a Literature Review (Task 2)

Site-specific data collected in Phase I (or earlier) will be used in the Phase II environmental assessment. Data available on aquatic and riparian environments and processes relating to the general vicinity of the site will be used. The Phase I investigation should provide most of the site-specific surface water and sediment data needed. Previous environmental studies provide general information on the ecology of the site, but site-specific data on biota will be collected during the Phase II environmental assessment.

Several sources will be consulted as part of the literature review to identify threatened and endangered species, as well as sensitive habitats, in the project area; these may include (but are not limited to):

- the Natural Heritage Program;
- Fish and Wildlife agencies;
- local college/university studies; and
- the available literature.

The result of the literature review will be a list of those species and habitat types likely to be present at the site. This will form a basis for activities performed in Tasks 3 and 4 and in the screening-level risk assessments.

### 6.5.3 Conducting Aquatic Environment Investigations (Task 3)

The aquatic investigations include:

- *habitat characterization; and*
- a *characterization of aquatic populations* (including a *fish population survey* and a *benthic macroinvertebrate survey*).

Based on the results of the above, the constituents and concentrations in the sediments, and predictions from hydrological modeling, the screening level risk assessment, including diversity analysis, will indicate whether a *species-specific fish survey* may be needed.

**Habitat Characterization**

The environmental risk evaluation will focus on the aquatic and riparian ecosystems of the Pawtuxet River in the region extending from the meander bend near Elmwood Avenue down to Rhodes-on-the-Pawtuxet. The facility reach and downstream reach may be a source of direct exposure of site-related constituents to resident fauna. The river upstream of the facility can serve as a reference area in evaluating less mobile fauna (e.g., benthos). The pond located in the Waste Water Treatment Area will also be included in this evaluation.

The habitat quality can be ascertained by characterizing the following parameters:

- flow characteristics;
- sedimentation characteristics;
- sediment grain size, organic content, and ammonia concentration;
- water quality parameters (i.e., biological and chemical oxygen demand, total dissolved and suspended solids, ammonia, nitrates/nitrites, total Kjeldahl nitrogen, phosphates, dissolved oxygen, pH, conductivity; and
- the availability of shelter, macrophytes, pools.

Sediment grain size, ammonia concentrations, and organic content will be collected during the benthic survey (discussed later). Information for the other parameters will be obtained from Phase I and additional Phase II studies. Although TOC and grain size will be measured during other field activities, the large variability of sediment and the need to correlate these data with the benthic community structure dictate these analyses. The additional water quality parameter measurements are needed to characterize the habitat and the quality of the baseline ecosystem. Samples will be taken at eight locations in the river and pond during the fish and benthic surveys (Figure 6-4). Essentially, the river morphology and shelter availability (particularly aquatic macrophytes) are habitat descriptors. Physical observations will be made during all field surveys. Macrophyte species will be identified and mapped along the river during the fish and benthic surveys.

Forested upland, field, and wetland habitat occur along the Pawtuxet River study area. There is no evidence that these areas are directly affected by releases from the site. Species that feed in the river use these habitats as nesting and resting areas. Therefore, although the study will not address the terrestrial and wetland ecosystems specifically, these habitats will be characterized (physiognomy and dominant vegetation species association) and mapped to support interpretation of data concerning waterfowl and mammalian populations that rely on aquatic food resources.

**<u>Characterization of Aquatic Populations</u>**

A survey of the fish and macroinvertebrate communities in the Pawtuxet River and the pond in the Waste Water Treatment Area (WWTA) will be performed. Collection permits will be obtained from the appropriate authorities before field activities begin.

The results of the population surveys will be compared to information obtained in the literature review (Task 2) for the purpose of identifying state or federally listed threatened, endangered, sensitive or candidate species, as well as sensitive habitats.

<u>Fish Population Survey</u>

A fish survey of the Pawtuxet River will be performed using a boat-mounted electroshocker for sample collection. The electroshocker unit (Smith-Root, Inc., Vancouver, WA) will be mounted on a 16-foot aluminum boat and will deliver 360 to 504 volts of direct current at 60 pulses per second. The duration of the electroshocking events will be recorded to calculate catch-per-unit-effort. The survey of the WWTA pond will use a back-pack mounted electroshocker (Smith-Root Type VII Electrofisher).

Whenever applicable, captured fish will be held briefly for examination and recording of data, photographed, and then released. Age estimates of fish will be made in the field by an experienced fisheries biologist and will be based on length measurements and general condition.

Seven sampling transects in the Pawtuxet River and one in the WWTA pond will be used in the fish survey; these transects are shown in Figure 6-4. One reference transect in the river will be located far upstream of the facility (F-00), one just upstream of the facility (F-01), three in the facility reach (F-03, F-05, and F-07), and two downstream of the facility (F-13 and F-20). These transects will be observed sequentially. It is expected that the majority of fish species collected will be those having a relatively small home range, such as carp, members of the sucker family (Catostomidae), and members of the sunfish family (Centrarchidae). If the majority of species encountered are those having larger home ranges, consideration will be given to extending the distance between the transects and re-sampling. Transects should not be moved to the extent that interpretations of differences between fish populations from different transects becomes too speculative.

Data collected in the survey will include species identification, species enumeration, length, weight, and any deformities, skin lesions, or other abnormalities observed. The physical characteristics of the sample collection location also will be recorded. At a minimum, information will be collected as to water depth, current velocity, bottom substrate composition, and amount of available cover, including both terrestrial vegetation (shade) and aquatic macrophytes.

This survey will:

- evaluate impairment in the vicinity of the site as indicated by differences in populations throughout the river and by comparison to potential baseline communities;
- provide information on the food web in the vicinity of the site; and
- identify populations at risk under current conditions or potentially at risk under remedial measures.

No additional collections of fish for histopathological examination and/or tissue analysis of contaminant burden are planned. For these potentially highly mobile species in a dynamic river system, it would not be possible to develop a strict cause-and-effect relationship between contaminant burdens measured in fish tissue and the presence of site-related contaminants in the river. Given that other contaminant sources impact the river, chemical analysis of fish tissue would likely be inconclusive and may contribute to uncertainty regarding the site's contribution of any ecological effects. Unceratinty in the food chain model will be addressed through use of conservative assumptions and parameters so that there will be a tendency to overestimate risk; which is an appropriate situation for a screening-level assessment

<u>Benthic Macroinvertebrate Survey</u>

Benthic macroinvertebrates inhabiting riverine sediments include insects, annelids, mollusks, flatworms, and crustaceans that may be herbivores, carnivores, or omnivores. (In a well-balanced system, it is likely that all three types will be present). Trophic levels include deposit and detritus feeders, parasites, scavengers, grazers, and predators. As a result, these organisms are important members of the food web, and their health is reflected in the health of the higher forms (e.g., fish). Because the macroinvertebrate community in an aquatic ecosystem is very sensitive to stress, the community is a useful tool for detecting environmental perturbations from contaminants or naturally occurring stressors.

The benthic survey locations will be the 17 locations (SD-00M, SD-00L, SD-01R, SD-02R, SD-02L, SD-03R, SD-04R, SD-05M, SD-05L, SD-06R, SD-07L, SD-08M, SD-09R, SD-10M, SD-13R, SD-16L, and SD-20M) sampled for the Phase I sediment bioassays (shown in Figures 3-5 and 3-9). Two additional locations will be sampled in the WWTA pond. To the extent possible given the habitat characteristics present, benthos will be sampled from areas having comparable sediment types and flow regimes. Minimizing habitat variation will allow the identification of population/species composition differences resulting from other factors, such as chemical contamination. A steel rod will be used to probe bottom sediments, and samples will be collected from soft, fine sand and silt areas wherever possible. The benthos will be surveyed in late spring or early summer and early fall when benthic populations are at or near yearly maxima.

Because the depth of the Pawtuxet River precludes using Surber or Hess samplers, a Ponar or Ekman grab sampler will be used to collect benthic macroinvertebrate samples following methods set forth in ASTM D4342-84 (*Standard Practice for Collecting Benthic Macroinvertebrates with Ponar Grab Sampler*) and ASTM D4343-84 (*Standard Practice for Collecting Benthic Macro-invertebrates with Ekman Grab Sampler*). Samples will be sieved in the field by placing the sample in a bucket, adding screened water and agitating to create a slurry, and then pouring through a U.S. Standard No. 35 sieve. (Field observations in Phase I indicated that the No. 35 sieve is appropriate for Pawtuxet River sediments.) Samples will be preserved in a 10% buffered formalin solution; sample labels will be placed inside and affixed to the outside of the sample containers. The labels will include the sample identification number, name of the water body, sampling location, date, sampling device used, name of sample collector, substrate characteristics, depth, and any other data deemed pertinent. Three replicate samples will be collected at each sampling location.

Data collected from the benthic survey will include enumeration and identification to genus or to the lowest practical taxon. The physical characteristics of the specific sample collection area will be recorded. A sample of substrate from each location will be analyzed for grain size, total organic carbon (TOC) content, and ammonia.

This survey will:

- identify populations at risk under current conditions or potentially at risk under remedial measures;
- investigate the presence or absence of endangered species including the Barrens Bluet Damselfly (*Enallagma recurvatum*)* and the Banded Bog Skimmer Dragonfly (*Williamsonia lintneri*)*;
- evaluate impairment as measured by 1) the presence or absence of indicator species, and 2) differences in community structure (determined by community indices and multivariate analyses);
- determine the applicability of bioassay test organisms by verifying the presence of chironomid larvae in the existing benthic macroinvertebrate community; and
- provide the information needed to determine food webs in the vicinity of the site.

Note: habitat characteristics will be evaluated during the species/population/community structure analyses to ensure that variations due to habitat heterogeneity are not misconstrued as site-related impacts.

(*These species are listed as state endangered species by the Rhode Island Natural Heritage Program. Both species have aquatic larval stages. However, based on their preferred habitat types, it is unlikely that either species will be found in the Pawtuxet River).

The benthic macroinvertebrate community will be assessed as a potential receptor through comparisons of community indices (such as richness, evenness, and diversity as well as the presence/absence of tolerant/sensitive species). Richness is a measure of the number of species within a community. Evenness is a measure of similarity in abundance between species in a community. Diversity is a single statistic into which the number of species and the relative abundance among species are incorporated. It is high for a collection with many species when the abundance is similar among them, and is low when species are few and their abundances different.

The Shannon index of diversity will be applied in this study (Pielou, 1977). The Shannon index is the most widely used index in community ecology, and has been used to evaluate the response of a broad range of aquatic communities to various types of stressors. The expected Shannon Diversity value is usually less than 1 for areas of heavy pollution, between 1 and 3 in areas of moderate pollution, and greater than 3 in clean water areas (Wilhm and Dorris, 1968).

Given that the diversity calculation depends upon independent properties of a community, ambiguity is inevitable. A community with few species that are evenly distributed may have a calculated diversity value similar to a community with many species and uneven abundance. In order to correctly interpret diversity values it is essential to also calculate evenness, for which a number of methods are in use (Ludwig and Reynolds, 1988). Evenness will be calculated by the method of Pielou (1977), which expresses evenness as the ratio of the calculated diversity to the maximum diversity for a community.

Flow velocity, substrate composition, and stability, grain size, relative abundance of vegetation, and any other pertinent habitat information noted in the field will be considered when evaluating the results of the aquatic surveys. If differences are noticed in these parameters, it may be difficult to relate indices differences to site-related contaminants.

A report will be generated as a result of the screening-level risk assessment. This report will present:

- the results of the screening level risk assessment including the identification of constituents which may pose a significant risk to the environment;
- data gaps identified during the course of the risk assessment; and
- the need, if one exists, for additional studies. This report will also propose those studies, if necessary.

### 6.5.4 Conducting Terrestrial Environment Investigations (Task 4)

Based on chemical analyses and bioassays, a potential concern for the Pawtuxet River aquatic community was raised in Phase I. However, any effect on riparian/terrestrial communities with potential exposure to constituents in the Pawutuxet River has not been addressed adequately. The riparian investigations will be based on an initial review of background information. The investigations will include a *site visit* by field biologists and a *screening-level risk assessment*. Any further riparian surveys will be undertaken only if the results of the screening assessment show significant concern.

A determination of "significant concern" will be based on the results of the screening-level risk assessment models. If the hazard quotient for a certain constituent of concern in one of the indicator species is equal to or greater than one based on a comparison of estimated daily intake to acceptable daily intake levels, then it will be concluded that potential risks exist for the specific indicator species.

**Site Visit**

A site visit will be performed by field biologists in order to characterize the riparian/ terrestrial ecosystems. During this visit, habitat types will be noted and mapped. All wildlife (or signs thereof) observed also will be recorded. Plant communities will be described and the component species will be identified. Evaluation of the types of vegetation present will provide insight into the bird and mammal species that may be present, as well as information on potential contaminant pathways. The objective of the site visit is to produce a list of species potentially in the area and potentially at risk of exposure to consituents in the Pawtuxet River.

**Screening-Level Risk Assessment**

A screening-level risk assessment will be conducted for the biological receptors associated with the Pawtuxet River, contaminated media, and constituents of potential concern that have been identified. The biological receptors (indicator species) to be used in the screening-level risk assessment will be organisms that are:

- chronically exposed to site-related chemicals; or
- endangered or threatened; or
- of economic importance; or
- exposed to site-related chemicals via food web transfer or other secondary pathways.

Potential exposure of receptors may occur by primary pathways or by secondary pathways involving the transfer of constituents through a food chain or web. Potential exposure pathways will be evaluated for each of the indicator species identified.

The *estimated daily dose* (mg chemical/kg body weight/day) of each constituent of potential concern will be determined for each indicator species based on simple and conservative models employing environmental concentrations of constituents and daily intake through all major pathways. An *acceptable daily dose* will be estimated by extrapolating from toxicity data in the scientific literature. Extrapolation from data using surrogate chemicals or surrogate species may be necessary if more specific data are not available. The acceptable daily dose will be compared to the estimated daily dose using a hazard quotient (HQ) methodology. HQ values > 1.0 indicate that exposure is greater than acceptable levels, values < 1.0 indicate that it is not, and 1.0 indicates that exposure equals acceptable levels. A HQ is not a direct measure of risk, but merely a convenient method for indicating exceedence of acceptable values.

A screening-level risk assessment report for riparian receptors will be generated. This report will:

1. present the results of the assessment based on the literature review, site visit, and screening-level models;
2. identify any data gaps identified during the assessment; and
3. determine the need for additional studies, if necessary.

If the screening-level risk assessment for riparian receptors finds no HQ values greater than 1.0 (i.e., a low probabilty of signficant risk) then this will be documented in the report and no further riparian investigations will be proposed.

<u>**Riparian Surveys**</u>

The riparian surveys (including a *mammalian survey*, a *herpetile survey*, and a *bird survey*) will be performed only if the results of the screening-level risk assessment indicate HQ values greater than 1.0. The objective of the riparian surveys would be to identify significant species of mammals, herpetiles, and birds along the Pawtuxet River that may be impacted by exposure to site-related chemicals. This objective would be met by:

1. determining the presence and estimated numbers of rare, endangered, sensitive species (either Federal- or State-designated), or sensitive habitats;
2. determining the species and estimated numbers of small mammals, herpetiles, and birds that use the river as feeding habitat;
3. determining the presence of a species of economic or scientific importance; and
4. determining the effects of environmental contaminants on these species, if any.

Mammalian Survey

Mammals in the area of the Pawtuxet River facility would be surveyed by nocturnal observations and habitat searches. Nocturnal observations would be made (either along transects at selected roadside vantage points or from a boat on the river) using a AN/PVS-4 Night Visions System Starlight scope. This scope allows the observer to sight and photograph nocturnal animals without inducing behavioral responses. Habitat searches will be conducted using the belt transect method; mammal signs (including sightings, tracks, burrows, runs, spoor, and carcasses) will be recorded.

These surveys will:

- identify species that may potentially be exposed to site-related chemicals;
- provide information necessary for the ecological assessment; and
- help in determining the food web in the vicinity of the site.

Herpetile Survey

The herpetological fauna in and using the Pawtuxet River will be sampled using four techniques. During the fish survey, any amphibian caught in the nets or electroshocked will be noted and released. In addition, minnow traps will be placed in appropriate breeding areas along the edge of the river to collect aquatic salamanders. Frogs will be monitored 1) by diurnal observation and collection, and 2) during the nocturnal bird survey. River banks and areas containing aquatic vegetation will be spotlighted and data on species identity, abundance, and location will be noted. During the nocturnal survey, all frogs heard calling will be identified by the call. In addition, a series of prerecorded calls of species known to be in the area will be played on a game caller. Frogs are strongly territorial; they interpret the artificial call as belonging to a rival male and (generally) will respond, which helps to confirm their presence.

Most amphibians constitute the tertiary consumer level in the food chain. Many fish and birds prey on amphibians, so contaminants accumulating in the lower trophic levels might be funnelled up the food chain through amphibians. Many of the organisms that feed on amphibians (e.g., bass and herons) are important economically or recreationally.

Any reptiles (snakes and turtles) sighted during the nocturnal survey also will be noted. In addition, any turtles that are basking will be noted, and turtle traps will be placed near known basking locations (as well as at other appropriate sites along the edge of the river). Traps will be checked daily; any turtles caught will be identified, marked, and released. Because turtles (especially snapping turtles) are noted for their tendency to bioaccumulate contaminants, they typically are an excellent upper-level predator to sample.

In addition to the river-intensive surveys, nocturnal road cruising will be performed on roads near the river. Road cruising allows rapid sampling of large areas for herpetiles moving to and from breeding, nesting, or feeding habitat. Rainy evenings tend to produce the most diverse results using this method because amphibians become more surface-active under these conditions. Overall, the data from the Phase II herpetile survey will:

- identify species endemic to the areas of concern;
- provide information necessary for the ecological assessment evaluation; and
- help in determining the food web in the vicinity of the facility.

<u>Bird Surveys</u>

Avifaunal studies will be conducted in the winter and summer to focus on resident populations using the riverine habitat. Particular attention will be paid to waterfowl and raptors (predators) in the vicinity of the Pawtuxet River and the WWTA pond. The early morning hours are particularly good for sighting birds. In addition, nocturnal observations along the same transects will be made to identify nocturnal birds (e.g., night herons).

A transect survey technique will be used; observation periods will be 15 minutes at each location on a transect. Species observed, time, date, location, habitat, and behavior will be recorded for each location. This survey will:

- identify species endemic to the areas of concern;
- determine presence or absence of endangered species including the American Bittern (*Botaurus lentiginus*)*, the Northern Harrier (*Circus cyaneus*)*, the Roseate Tern (*Sterna dougallii*)*, the Yellow-breasted Chat (*Icteria virens*)* and the Vesper Sparrow (*Pooecetes gramineus*)*;
- evaluate habitat suitability for endangered species that could potentially reside in the area;
- provide information necessary for the ecological assessment evaluation; and
- help in determining the food web in the vicinity of the facility.

*(These species are listed as state endangered species by the Rhode Island Natural Heritage Program (RINHP). Based on information obtained from RINHP, it is unlikely that any of these species would find suitable breeding habitat in the vicinity of the Ciba-Geigy Cranston site).

**6.5.5 Performing an Ecological Assessment of the Pawtuxet River (Task 5)**

The ecological (risk) assessment of the Pawtuxet River includes an *exposure assessment*, an *ecological effects assessment*, and a *risk characterization*.

**Exposure Assessment**

The exposure assessment will describe how the constituents (in, or transported by, the river) reach the river and WWTA pond ecosystems and define the biological populations at risk. The exposure assessment estimates or measures the amount of each constituent released, tracing it through a pathway to the receptor, and involves two main activities — an *exposure pathway analysis* and *selection of target species*.

Exposure Pathway Analysis

An exposure pathway determines how a constituent can be transported from its source to a receptor in the environment. A potential exposure pathway has five components:

1. a constituent source;
2. a mechanism for contaminant release;
3. an environmental transport medium;
4. an exposure point (receptor location); and

5. a route of exposure.

Integrating the biological investigations with the results from other Phase II studies (and with information available in the scientific literature) will provide the information needed so that the exposure pathway analysis can answer the following questions:

- What receptors are actually or potentially exposed to site-related constituents in the river?
- What are the significant routes of exposure?
- To what concentrations of each constituent are the receptors actually or potentially exposed?
- What is the duration of exposure?
- What is the frequency of exposure?
- What seasonal and climatic variations are likely to affect exposure?
- What are the site-specific geophysical, physical, and chemical conditions affecting exposure?

Selection of Target Species

Target species, target communities, and critical habitats will be selected using five criteria:

- Susceptibility of the species, community, or habitat to site-related constituents associated with the river;
- Relationships between the target species, community, or habitat and the exposure pathways;
- Amount of information in the literature on the target species, community, or habitat;
- Potential for bioaccumulation or biomagnification of the constituents in the target species; and
- Prior success with evaluating toxic effects, based on the scientific literature, for the target species.

**Ecological Effects Assessment**

The toxicity assessment weighs the evidence available about the potential for a particular constituent to cause an adverse effect in exposed receptors (target species). It also estimates, where possible, the relationship between the extent of exposure to a constituent and the increased likelihood and/or severity of adverse effects. The toxicity assessment involves three main activities — *ecotoxicological analysis*, *stressor-response profile*, and *determination of ecological endpoints*.

Ectoxicological Analysis

Environmental toxicity information will be obtained for all constituents of concern. If there are constituents without available toxicity information, consideration will be given to an evaluation using toxicity information from compounds exhibiting similar physical/chemical properties and similar biological activities, as is often done in human health risk assessments. Also, much of the evidence available is likely based on laboratory experiments using single species exposed to a single constituent, or on field experiments conducted under conditions that may be much different from those at the facility. The variables that influence toxicity include the nature of the target species, laboratory conditions, the nature of the constituent, concentrations of the constituent, and the duration of exposure. All of these variables will be considered in the hazard identification process, as well as discussed in the uncertainty analysis section.

Stressor-Response Profile

Dose-response assessment is the process of quantitatively evaluating the toxicity data and characterizing the relationship between the dose of the constituent received and the incidence of adverse effects in the exposed population. Toxicity values derived from this quantitative dose-response relationship can be used to estimate the incidence of (or potential for) adverse effects as a function of receptor exposure to a constituent. For this assessment, the estimated applied daily dose will be compared to the acceptable applied daily dose for each constituent of concern to determine whether adverse effects would be expected for each indicator species.

Determination of Ecological Endpoints

An ecological assessment must define site-specific assessment endpoints, with associated measurement endpoints. An assessment endpoint is a formal expression of the actual environmental values that are to be protected; a measurement endpoint is a measurable ecological characteristic that is relatable to the valued environmental characteristic chosen as an assessment endpoint. Assessment endpoints will be based on potential effects at the individual and population levels of biological organization, as these are usually better defined and more predictable with current data and methods than are responses at these higher levels of biological organization. Toxic effects from exposure to constituents may take the form of reduced reproductive success in individual organisms and such potential adverse effects could lead directly to a reduction in total population abundance for site-specific ecological receptors. Measurement endpoints will be published results of laboratory or field toxicity tests performed on fish, mammal, and avian species that share an operational relationship with previously defined assessment endpoints; they will serve as surrogates for the assessment endpoints. Endpoints that may be appropriate for this phase of the Pawtuxet River assessment process are summarized in Table 6-X. The field investigations proposed for the Phase II environmental assessment are designed to attempt to provide the data needed to evaluate certain community and population endpoints in the Pawtuxet River.

**Risk Characterization**

Information from data evaluations, field investigations, and exposure and toxicity assessments will be summarized and integrated into quantitative and qualitative expressions of potential risk to plants and animals from site-related constituents. Media-specific constituent concentrations and known environmental criteria will be compared to characterize potential biological effects. The risk characterization involves two main activities — a *risk analysis* and an *uncertainty analysis*.

Risk Analysis

The potential risk posed by identified constituents related to releases from the facility will be assessed by:

- comparing exposure point concentrations to published criteria or doses with known adverse effects;
- comparing on-site ecological populations of plants or animals existing in affected areas to those existing in upstream (reference) areas; or
- comparing estimated daily intakes to acceptable daily intakes for each constituent of concern for the exposed indicator species.

Note: For the present investigation, reference area comparisons will be made only for the benthic macroinvertebrate survey and the fish survey. The reference stations will be located upstream from the site to eliminate the possibility of contamination from site-related constituents. In addition, the reference stations will be located in stream areas with similar physical characteristics (flow velocity, depth, substrate type, cover) to the stations sampled within the zone of potential contamination.

Uncertainty Analysis

All risk estimates depend on numerous assumptions and contain many uncertainties that are introduced throughout the evaluation process. Uncertainties are inherent in selection of sampling locations, chemical analysis methods, field survey techniques, conduct of media and biota sampling operations, and interpretation of toxicological data. Variables that influence toxicological data and, thus, contribute to uncertainty are; the nature of the target species, laboratory conditions, the nature of the constituent, concentration of the constituent, and the duration of exposure. In any evaluation of the level of risk associated with a site, it is necessary to address the level of confidence. (i.e., or the uncertainty associated with the estimated risk).

Two major areas of uncertainty exist in the screening-level risk assessment models:

1. Daily intakes are calculated by estimating daily intakes of food, water, and air for each indicator species. These daily intakes are either literature values or estimations based on body size and metabolic rates. Allometric equations are used to describe the relationship between body weight and food or water consumption rate. Such allometric equations are available between different fish classes, birds and mammals. These estimations introduce uncertainty into this assessment.

2. Acceptable daily intakes for each indicator species are based on maximum dosages that are not expected to have long term adverse effects on the animal. Since these values may not exist for each indicator species and each constituent of concern, values from similar species may have to be used. Also, many of these values are derived from laboratory tests using only one chemical. Uncertainty is introduced into this assessment since the animals on-site will be exposed to a

combination of chemicals under different environmental conditions than those in the laboratory.

Uncertainty may also be introduced by the presence of anthropogenic stressors not related to the site that may confound interpretation of impacts produced by the site.

## 6.6 CONSIDERATIONS FOR THE PHASE II ENVIRONMENTAL ASSESSMENT

Other considerations for the Phase II environmental assessment of the Pawtuxet River — including integration of the environmental data with other Phase II studies, as well as contingencies for the Phase II environmental assessment — are discussed here.

### Integration with Other Phase II Studies

As discussed earlier, the results from the hydrological investigation and Pawtuxet River release characterization will be integrated and used to support the Phase II environmental assessment.

### Contingencies for the Phase II Environmental Assessment

The field investigations are designed to be conducted in appropriate seasons; completion of these investigations on schedule is contingent on 1) beginning all tasks on schedule, and 2) obtaining appropriate collection permits on schedule. The decision to conduct species-specific fish or riparian surveys are contingent on the result of the screening level assessment and the risk assessment report and may be contingent on completion of the 1) release characterization of sediment, and 2) hydrological modeling.

## 6.7 SUMMARY

The Phase II environmental assessment will assess the risk to the Pawtuxet River environment with regard to site-related contaminants. The strategy for the Phase II environmental assessment involves:

- conducting toxicity identification evaluations;
- conducting a literature review;
- conducting surveys of benthos, fish, mammals, herpetiles, and birds in and around the Pawtuxet River; and
- integrating the findings to characterize potential biological effects.

The next chapter discusses project management issues for the Phase II river investigations.

- An ecological characterization of the upstream reach, including basic water quality data and an inventory of biota, is needed to establish baseline conditions.
- Characterization of the biota is needed to determine whether the ecotoxicological effects identified in Phase I have had an impact on the community.
- The vicinity of the site contains a variety of suitable habitats (e.g., woodlands, wet-lands, and the river) for resident and migratory mammals, birds, and waterfowl; the identity of possible receptors of site-related constituents needs to be determined.
- The presence or absence of State- or Federally-designated threatened or endangered species or other sensitive natural resources needs to be ascertained.
- The exposure scenarios of the potential receptors to the constituents need to be identified.
- The risk of effects due to exposure needs to be characterized.
- The contribution of constituents to observed toxicity needs to be identified in order to discriminate site-related effects.

The Phase II environmental assessment will assess the risk to the Pawtuxet River environment with regard to site-related contaminants. The strategy for the Phase II environmental assessment involves:

- conducting toxicity identification evaluations;
- conducting a literature review;
- conducting surveys of benthos, fish, mammals, herpetiles, and birds in and around the Pawtuxet River; and
- integrating the findings to characterize potential biological effects.

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# TABLE 6-2
# PROPOSED ECOLOGICAL ENDPOINTS FOR THE PAWTUXET RIVER ASSESSMENT

| ASSESSMENT GOAL | ASSESSMENT ENDPOINT | INDICATORS OF EFFECTS | MEASUREMENT ENDPOINTS |
|---|---|---|---|
| Minimal impacts to aquatic species; primarily aquatic vertebrates | (a) No probability for a reduction of >10% in population abundance of fish or invertebrate species [a] | (1) laboratory toxicity to common fish test species<br>(2) laboratory toxicity to common invertebrate test species<br>(3) species-specific field or laboratory toxicity data<br>(4) benthic community parameters with respect to a reference location<br>(5) sediment bioassay tests<br>(6) surface water bioassay tests<br>(7) pore water bioassay tests | fish NOEL<br>aquatic invertebrate NOEL<br>community indicies<br>species richness (S)<br>species diversity (H')<br>species dominance (D)<br>reduced survivorship in laboratory tests or in comparison to a "reference" area |
| Minimal impacts to piscivorous terrestrial wildlife and avian species | (b) No probability for a reduction of >10% in population abundance of piscivorous wildlife or avian species | (1) laboratory toxicity to common avian test species<br>(2) laboratory toxicity to common mammalian test species<br>(3) species-specific field or laboratory toxicity data | avian NOEL<br>mammal NOEL |
| No impacts to endangered or protected piscivorous wildlife species (e.g., migratory birds) | (c) No probability for any reduction in populations of protected piscivorous wildlife species | (1) laboratory toxicity to common avian test species<br>(2) laboratory toxicity to common mammalian test species<br>(3) species-specific field or laboratory toxicity data | avian NOEL<br>mammal NOEL |

[a] A 10% level of population effects is approximately the limit of detection of field measurement techniques and is likley below the detection limits of the public (e.g., catch-and-release fishermen).

Cline, 1977) has successfully predicted the photodecomposition of chemicals in pure water and has been incorporated in WASTOX.

The river will be represented in the model by three segments across the width and 26 divisions in the longitudinal direction, for a total of 78 water column segments. This segmentation represents an aggregation of the 360 element grid discussed as part of the sediment sampling plan. Initial model runs were attempted with a 360 water column segment model identical to the 360 element sampling grid, however, solution times were excessive. Solution times in the 78 water column segment model are reduced by two factors. The first factor is simply the ratio of the number of segments and the second is based on the increase in the minimum integration step dictated by the finite difference solution scheme.

The contaminant fate model will be include a vertical column of segments under each water column segment. The number of sediment segment layers and the thickness of each will be based on the vertical concentration profiles of the sediment contaminants. Thinner layers will be used to accurately resolve the observed profiles where vertical gradients are most significant and thicker layers will be used to represent well mixed portions of the sediment. (In other studies, three layers of sediment segments have produced satisfactory results.) The total depth of the sediment segments will be based on both the sediment concentration profiles and the results of the sediment transport model, which will indicate the depth of sediment which could potentially influence overlying water concentrations during resuspension events. Sediment transport analyses conducted to date indicate that maximum depths of resuspension in local areas would be near 16 cm under a 100-year flood. Based on this information the current sampling plan, to a depth of 40 cm will be sufficient.

In addition to suspended solids, the model will include concentrations of contaminants entering the upstream boundary, as well as estimates of inputs to the river within the modeled reach from sources such as groundwater inflow. Interactions between the sediment bed and the water column will be included. The period for which routine water column monitoring data are available will be the time period used for model calibration. Sediment bed contaminant concentrations will be assigned for each sediment segment based on the Phase II bed contaminant sampling results. Calibration will involve adjusting the coefficients that describe the relevant transformation processes to achieve agreement between measured and computed water column contaminant concentrations.

The adjustment of coefficients will be limited to ranges reported in the literature.

### E.4.9 Sensitivity Analyses

Analyses will be performed to evaluate the sensitivity of model calibration results to changes in model input parameters and assumptions associated with upstream boundary conditions. The sediment transport and chemical fate models which will be applied in this project are state of the art models requiring substantial computer resources. Only those simplifying assumptions necessary to make the solution tractable on a mini-super computer have been included in these frameworks. The assumptions associated with the model frameworks will not be included in this sensitivity analysis. Model calibration will include assumptions of the relationship between upstream river flow and upstream boundary concentrations of suspended solids and contaminants. Analyses will be performed to evaluate the sensivity of the model calibration to assumptions of upstream boundary conditions. Analyses will also be performed to evaluate the sensitivity of the model calibration to changes in the following model input parameters:

- Particle Settling Speed
- Site Specific Resuspension Parameter
- Diffusivity between the Sediment Bed and the Water Column
- Partition Coefficient
- Degradation Rate
- Henry's Constant

These analyses will identify the relative sensitivity of computed concentrations to changes in model inputs. Those parameters which produce greater changes in computed concentrations will require more precise assignment, while less certainty in parameter assignment will be required for those inputs to which the computed results are insensitive.

### E.4.10 Projecting Future Contaminant Concentrations

The calibrated contaminant fate model can serve as a management tool — it will be used to evaluate the response of contaminant concentrations in the river to possible remediation alternatives. The model also would project the response of water column contaminant concentrations to changes in inputs (such as groundwater).

## E.5 SUMMARY

A coupled hydrodynamic/sediment transport/chemical fate model will be developed and calibrated/verified during Phase II. The model domain will extend from Cranston to the Pawtuxet Cove Dam with adequate resolution for the accuracy requirements of this study. A two-dimensional, vertically-integrated hydrodynamic model will be used to account for lateral variations in river velocities. The sediment transport model will simulate the resuspension, deposition and fate of cohesive and non-cohesive sediments. All significant processes will be included in the chemical fate modeling framework. Historical data will be added to Phase I data. Phase II field study results will be added to the data base as they become available. Stage height data will be used to calibrate and verify the hydrodynamic model. A bed sediment map will be generated from the results of the bed characterization study. The in-situ resuspension potential of cohesive sediments will be measured. Contaminant concentration data in the water column and the sediment bed will be analyzed to determine spatial and temporal trends. Storm surveys will be conducted to provide suspended solids and contaminant data during high flow events. The available data will be used to calibrate and verify all three numerical models. Erosional effects of a 100-year flood will be determined using the hydrodynamic and sediment transport models. The calibrated/verified chemical fate model can be used to predict the effects of various remedial options. The schedule for these tasks is presented in Figure 7-2.

## APPENDIX F
## BASIS FOR PHASE II RELEASE CHARACTERIZATION SAMPLING PLAN FOR THE LOWER FACILITY REACH

The proposed sampling plan for the Phase II Release Characterization (Section 5.3.4) is comprised of two rounds. The plan states that in the lower facility reach Round 1 sediment samples will be collected to a depth of six inches (or to the penetration depth of the sampler). This data will be used to evaluate the horizontal extent of contamination. If contamination is detected in the lower facility reach from the Round 1 analytical results, the vertical extent of contamination in the lower facility reach will be evaluated in Round 2. If no contamination is detected in the lower facility reach in Round 1, evaluating the vertical extent of contamination in the lower facility reach will not be warranted. This section describes the basis for the proposal to evaluate the vertical extent of contamination in the Phase II Release Characterization sampling plan for the Lower Facility Reach. The following discussion addressed this issue through consideration of biological and contaminant transport issues.

Biological Considerations

The benthic community of the Pawtuxet River is dominated by tubificid worms and chironomid larvae. Also present are leeches, planeria, many families of insects, amphipods, isopods, decapods, snails and bivalves. The substrate of the Pawtuxet River is largely composed of sand or larger particles and has limited amounts of clay. The majority of the species identified are associated with surficial sediments through their ecology. Bivalves are filter feeders and depend on the stream current to provide a continuing source of food. Crustaceans rely on the course particulate organic matter of recent deposition for food. Oligochartis, which include the tubificid worms, however, feed through ingestion of sediment in the way that terrestrial earthworms do. Field surveys in the river indicate that the bulk of the macroinvertebrate biomass is concentrated at or above a depth of 10 cm. Due to the presence of a rocky substrate in the Pawtuxet River, no benthic biota were found below these surficial sediments along the length investigated. A literature review indicates that oligochaetes can occasionally be found to a maximum depth of 30 cm given that a suitable fine-particulate substrate (mud or silt) exists, which is not the case in the Pawtuxet River. For these reasons, the benthic community and nektonic species are expected to be associated with the surficial sediments and not the older, deeper sediments of the Pawtuxet River.

Contaminant Transport Considerations

The model that has been developed to simulate the suspended transport of fine-grained sediment, both cohesive and non-cohesive, in the Pawtuxet River utilizes the results of extensive laboratory and field studies to specify the parameters governing deposition and resuspension processes. The SEDZL modeling framework, which accurately and realistically simulates cohesive resuspension and deposition, including the effects of flocculation, has been modified to include the simulation of non-cohesive suspended transport. The need for including non-cohesive suspended load in these simulations is due to the presence of relatively high concentrations of total organic carbon (TOC), which adsorbs organic chemicals and heavy metals, in non-cohesive sediment bed deposits. Several field studies were conducted during the spring of 1992 to collect bathymetric, stage height, suspended solids and sediment bed data. The hydrodynamic and sediment transport models were calibrated and validated during a 33 day period, which included 2 high flow events, each of which approximately correspond to the annual flood. The successful calibration and validation exercise indicates that the model can be confidently used as a predictive tool.

Sediment transport in rivers is episodic by nature with a major fraction of the load transported during a few days of flooding each year. This characteristic of rivers makes it necessary to examine the effects of extreme events, i.e., rare floods, on the resuspension of sediments when considering the fate of contaminants residing in the sediment bed. Use of a calibrated and validated sediment transport model, that realistically simulates deposition and resuspension processes, makes it possible to quantitatively delineate the sources of suspended load in a riverine system. Spatial variations in sediment bed erosion can be predicted by the model for a particular flood. These predictions can then be coupled with measured sediment bed properties, e.g., grain size distribution and TOC concentration, to estimate the probabilities of contaminant resuspension.

A flood frequency analysis for the lower Pawtuxet River was carried out to estimate the magnitude of various extreme events. An analysis of 51 years of flow data collected at the USGS Cranston gauging station, from 1940 through 1990, was conducted using a standard USGS method for determining flood flow frequencies (USGS, 1981). This method utilizes a Log-Pearson Type III distribution to estimate flood flow frequencies. The results of this analysis indicated that flow rates of 3,500 and 5,200 cfs correspond to the 10-year and 100-year floods, respectively, downstream of the confluence of the Pocasset River. These high flow events can be contrasted to the mean flow rate of 410 cfs and the annual flood of 1,450 cfs.

The sediment transport model was used to examine the effects of the 10-year and 100-year floods on sediment bed erosion in the Pawtuxet River. Only resuspension was considered in these calculations, the upstream and tributary sediment loads were set to zero and assumed to have negligible effect on the total amount of bed erosion during the flood. The predicted erosional depths due to the 100-year flood in the vicinity of the facility are illustrated on Figure 1. Erosional depths are generally less than 0.2 cm in this reach, with a few small areas of erosion to depths greater than 1.0 cm (0.4 inch). This type of erosional pattern was predicted for the rest of the river; relatively shallow erosion in most of the river channel with small, localized pockets of deeper erosion. The results of these calculations indicate three small areas, defined by model segmentation, where significant erosion may occur during extreme flow events, see Figure 2. The depth of erosion in these segments ranges from 1.3 to 10.9 cm (0.5 to 4.3 inches) for the 10-year flood and from 3.5 to 15.9 cm (1.4 to 6.3 inches) for the 100-year flood. The areas, or segments, in which the highest erosion occurs are relatively small, with typical dimensions of 5 meters wide by 50 meters long. Outside of these segments, erosional depths typically range from 0.2 to 1.0 cm (less than 0.5 inch).

Results of the extreme event simulations indicate that sediment bed erosion to depths of 6 inches will only occur during rare floods, e.g., 100-year flood, and then only in very limited areas of the river. Thus, sediment bed contaminants available for resuspension in the Pawtuxet River can generally be regarded as limited to the top six inches of the bed. Contaminant concentrations obtained from a surficial sediment bed sample, i.e., collected from the top six inches of the bed, can confidently be assumed to represent all of the potential erodible mass of contaminants at the sample location, except possibly at the three locations indicated on Figure 2. Locations that yield surficial samples with non-detectable contaminant concentrations do not require retrieval of deeper cores and subsequent contaminant analysis at depths greater than six inches. Obtaining that data would not produce useful information for the contaminant fate and transport modeling effort.

Even though 3 small areas of potentially high resuspension have been identified through model simulations, with only 2 of the locations approaching six inches of erosion as a result of a 100-year flood, sampling deeper in the bed may not be automatically warranted in those areas. Those segments experience very high bottom shear stresses during floods, which causes the high erosion. The bathymetry and geometry of the Pawtuxet River create those areas of relatively high bottom shear stress, not only during flood conditions but also during normal flow conditions. This relatively high shear stress environment will tend to inhibit deposition in those locations; areas of high erosion during floods will typically have low deposition rates during low to moderate flow rates. Deep burial of contaminated sediments in areas of high erosion is thus unlikely. Therefore, if non-detectable contaminant concentrations are found in surficial samples obtained in the three areas of potentially high erosion, then deeper sampling is not warranted.